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Construction and demolition materials management in Hong Kong

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The management of construction and demolition materials is a problem being tackled by many government agencies worldwide. The problem is particularly acute in Hong Kong due to rapid economic development and urban renewal over recent decades, and the situation is aggravated by the dense population on a small plot of usable land. The Hong Kong Special Administrative Region (HKSAR) government is implementing many initiatives in both public and private sectors to handle the ever-increasing municipal problem. Some of these strategies and practice are reviewed in this paper. The effectiveness of these initiatives is being closely monitored by the HKSAR government and adjustments are being made from time to time as required.

1. INTRODUCTION

Although 'construction and demolition (C&D) waste' and 'construction waste' are terms used by many, the author refrains from using this terminology because C&D 'materials', if properly managed and/or processed, are not necessarily waste. In this paper, C&D materials are defined to be any substance generated by construction or demolition activities, regardless of whether or not it has been processed, stockpiled or abandoned. It is worth bearing in mind that the generation of C&D materials can increase dramatically and unexpectedly in the aftermath of natural disasters such as earthquakes, hurricanes, tornadoes and flooding.[1] The emergency actions required to handle the sudden generation of large quantities of C&D materials are, however, beyond the scope of this paper.

Proper routine management of C&D materials is a global problem existing in many economies,[1–5] primarily due to the shortage of landfill space for disposal. For example, C&D materials are considered to be one of the priority waste streams in the European Union waste strategy and actions have been recommended in the sixth environment action programme.[6] The board of directors of the US Northeast Waste Management Officials' Association (NEWMOA) has determined management of C&D materials to be a priority issue for the eight NEWMOA states to focus on as a region.[7] NEWMOA is a non-profit, non-partisan, interstate association; its membership is composed of state environmental agency directors of the hazardous waste, solid waste, waste site clean-up, pollution prevention and underground storage tank programmes in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont.

Historically, C&D materials have been routinely dumped in landfills. However, available landfill space is becoming increasingly limited and natural constraints and/or public opposition have severely limited the siting of new landfills worldwide. Diminishing landfill capacity and increasing costs of disposal have led to an increased emphasis on the processing of C&D materials to reduce volume for transport and disposal, and to transform them for new applications. The situation in Hong Kong (HK) is no exception.

According to data published by the HK Special Administrative Region (HKSAR) government,[8] the total area of the HKSAR is 1104 km^2, accommodating a population of 6·86 million (as of mid-2006) and a world-class financial, trading and business centre. However, most of the population is housed in 225 km^2 of urban development because of steep natural terrain and stringent planning controls. More than 400 km^2 of the territory has been designated as protected areas, including country parks, special areas and conservation zonings. The concentration of population and economic activities on such a small plot of usable land exerts intense pressures on the environment. Proper management of municipal solid waste and C&D materials is thus one of the major challenges facing the HKSAR government. The amount of different types of solid waste disposed of in landfill in HK from 1991 to 2006 is depicted in Fig. 1. The relative proportions of these wastes (the different types of solid waste in HK are defined by the environmental protection department (EPD) of the HKSAR government[9]) are shown in Fig. 2.

Hong Kong has enjoyed decades of rapid economic growth and infrastructure development. Moreover, the demand for better life quality has accelerated the progress of urban renewal. As a result, HK faces the challenge of management of a significant quantity of C&D materials generated by local construction and demolition activities. Data available from the EPD of the HKSAR government on the annual generation rate of C&D materials in HK from 1991 to 2006 are depicted in Fig. 3.

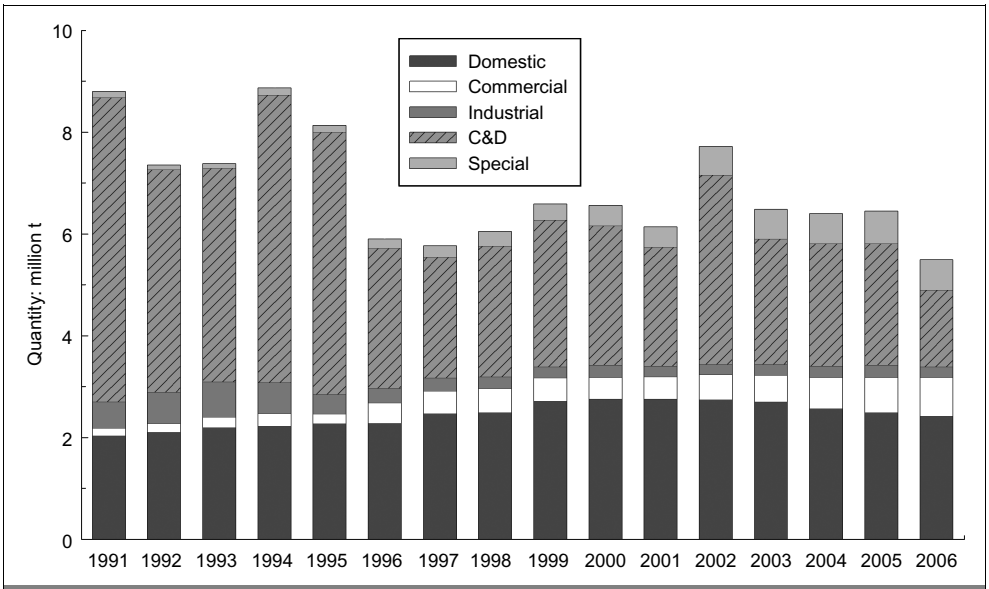

Fig. 1. Distribution of solid waste disposed of in landfills in Hong Kong by type

C&D materials in HK are a mixture of surplus materials arising from site clearance, excavation, construction, refurbishment, renovation, demolition and road works. As shown in Fig. 3, a significant proportion of these C&D materials are inert substances (known as public fill in HK) such as rocks, concrete, asphalt, rubble, bricks, stones and earth. When properly sorted, public fill is suitable for reuse in reclamation and site formation works. Moreover, hard materials such as rocks and concrete can be recycled as aggregates for concrete/asphalt production or as granular materials for the construction of road sub-base, drainage layers, and so on. The remaining non-inert substances in C&D materials include bamboo, timber, vegetation, packaging materials and other organic and perishable materials. Non-inert C&D waste is not suitable for land reclamation and/or other applications. Subject to recovery of reusable/recyclable items, it is dumped in landfill.

Figure 2 reveals that C&D waste comprised 27·4% (i.e. 4125 t/day) of total landfilled solid waste in 2006 in HK. In contrast to other countries (e.g. Greece[2]), HK has a well-established C&D materials collection network. Different sorting methods for recycling C&D materials have been evaluated by Huang *et al.*[1] and for HK in particular by Poon *et al.*[10] On-site sorting is considered to be the most effective sorting method in general.[1] Moreover, it is also considered by Poon *et al.*[10] and Lu *et al.*[11] to be the most effective sorting method for the conditions of HK. Collection and sorting of C&D materials for reuse and recycling thus pose no insurmountable operational problem in HK.

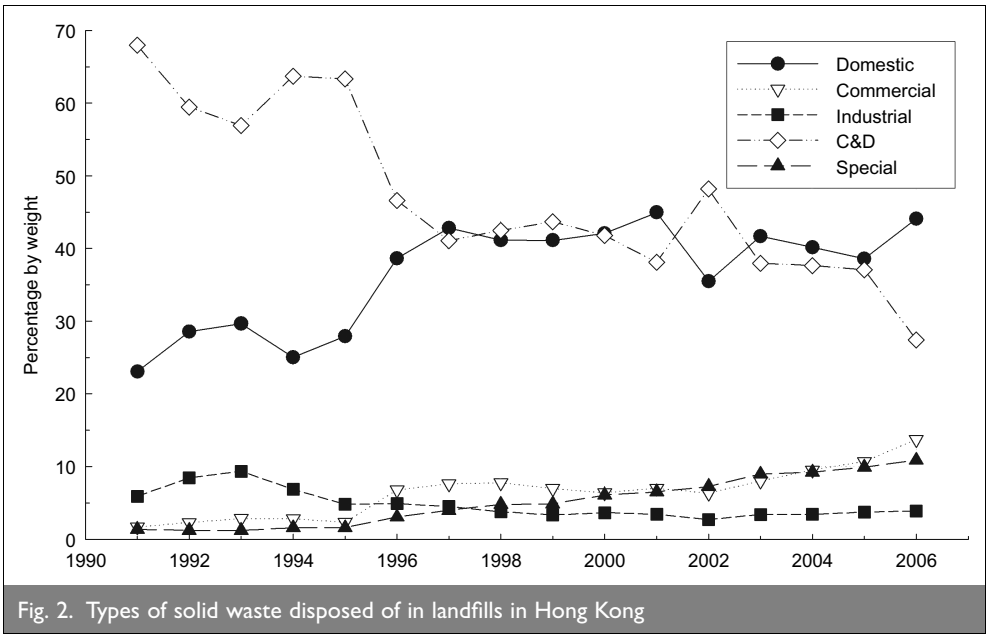

Fig. 2. Types of solid waste disposed of in landfills in Hong Kong

As illustrated in Fig. 3, public fill accounted for 23–89% (with an average of approximately 70%) of the total quantity of C&D materials generated in HK on an annual basis in 1991–2006. Beneficial uses of public fill will certainly reduce demand for storage capacities and waste disposal facilities. The HKSAR government is thus showing determination to promote the reuse and recycling of public fill as far as possible for the sustainable development of HK and to help preserve precious landfill space and public fill storage capacities. Furthermore, the HKSAR government is also promoting the recycling of other reusable building materials to minimise the generation of C&D waste. Some of these strategies and practice are presented in this paper.

2. CURRENT SITUATION IN HONG KONG

The majority of solid waste generated is disposed of in three large modern strategic engineered landfills in the New Territories (NT): north-eastern NT (NENT) landfill, south-eastern NT (SENT) landfill and west NT (WENT) landfill (labelled L1–L3, respectively, in Fig. 4). These landfills were designed for operation life up to the year 2020 followed by 30 years of aftercare. They are operated by specialist waste management contractors to high environmental standards. However, it costs US$16/t of waste landfilled to build and operate these landfills. Disposal of the useful inert components of C&D materials is not allowed.

The HK construction industry is generating C&D materials at an increasing rate as a result of rapid ongoing infrastructure development. As shown in Fig. 3, the annual production rate of

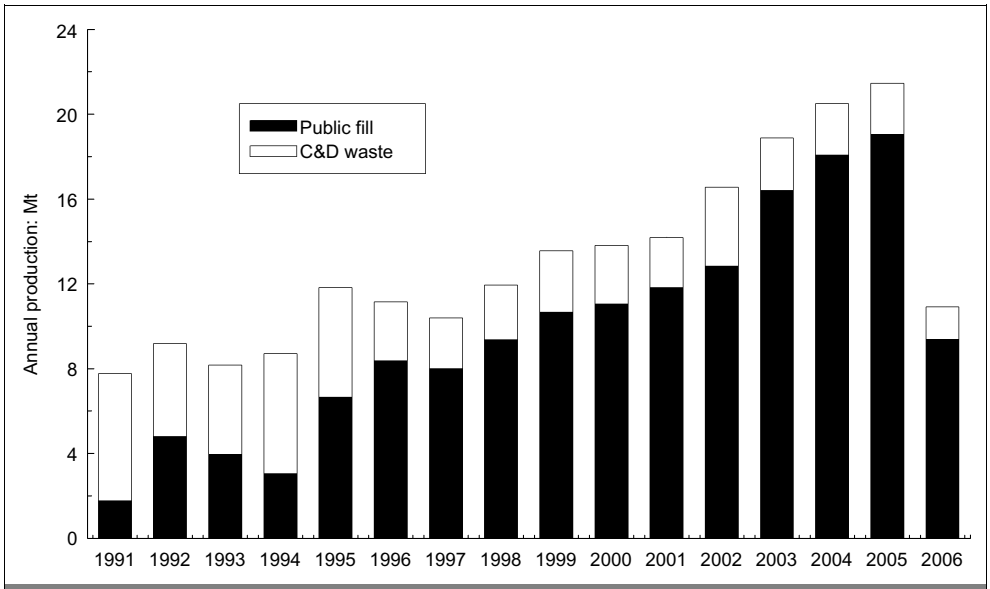

Fig. 3. Annual generation rate of C&D materials in Hong Kong

C&D materials increased from 7·76 Mt in 1991 to 21·45 Mt in 2005 (although decreased to 10·91 Mt in 2006). C&D materials are bulky and would occupy enormous landfill space if they were dumped in landfills. In November 1998, the HKSAR government launched a ten-year waste reduction framework plan (WRFP) to reverse the rising trend of waste growth to prolong the expected lifespan of landfills. However, with the end of the planning horizon of the WRFP approaching, a new strategy needs to be formulated.

Disposal of public fill at public filling areas and mixed C&D waste at sorting facilities or landfills has been the major approach for the management of C&D materials. However, as public concern about ecological impacts increases, HK can no longer rely solely on this reclamation to accept most of the inert public fill for sustainable development. The HKSAR government is examining ways and means to reduce the generation and to promote the reuse and recycling of C&D materials.[12–16] Nevertheless, there will still be a substantial amount of material that requires disposal, either at public fill reception facilities or in landfills.

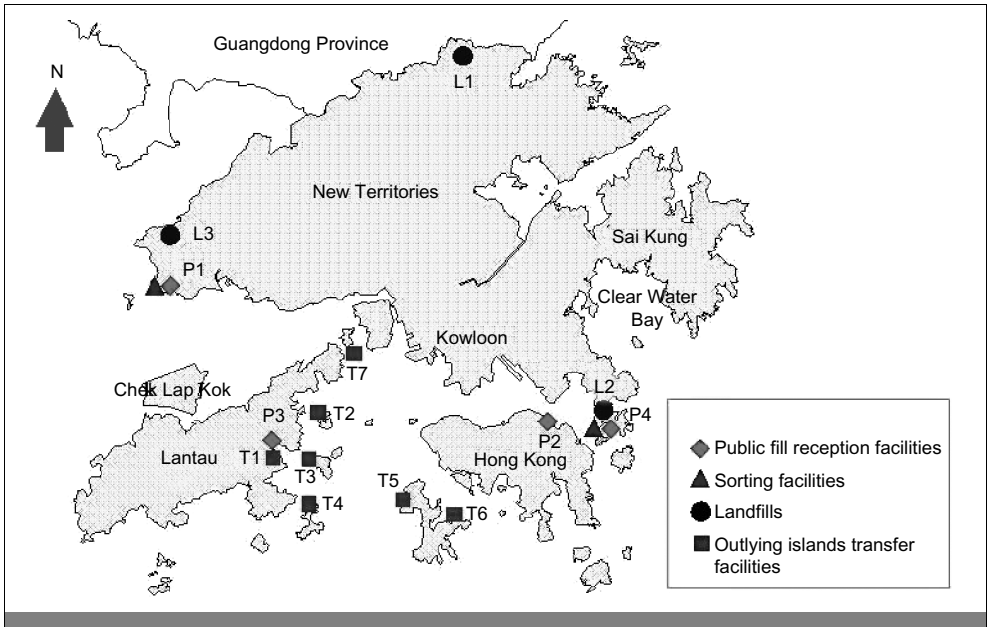

Fig. 4. Solid waste management facilities in Hong Kong

At present, both reclamation sites and landfill space are diminishing rapidly in HK. According to a study completed in January 2003 by the HKSAR government, all three strategic NT landfills would be filled in five to nine years from 2003 if waste levels continue along current trends. Moreover, public fill storage capacities can only last until 2008. If sufficient public fill storage capacities cannot be located and/or effective waste reduction measures cannot be implemented, more public fill would probably be dumped in landfills, resulting in further shortening of the already limited usable landfill life. If feasible solutions cannot be identified immediately, the crisis of lack of disposal space for the daily generation of thousands of tonnes of solid waste will become a formidable reality in HK in a few years' time. The situation is acute.

3. LEGAL FRAMEWORK

Seven ordinances on waste and pollution control operate in HK: the Waste Disposal Ordinance; the Water Pollution Control Ordinance; the Air Pollution Control Ordinance; the Noise Control Ordinance; the Ozone Layer Protection Ordinance; the Dumping at Sea Ordinance; and the Environmental Impact Assessment Ordinance. Legislative details of these are publicly available.[17] The Waste Disposal Ordinance was enacted to control waste disposal, including collection and disposal and the import and export of waste. The Dumping at Sea Ordinance was enacted to control disposal of dredged mud and excavated materials at designated marine disposal sites. These two are thus of the most direct relevance to the management of C&D materials in HK. In particular, the Waste Disposal Ordinance is the backbone legislation of many government initiatives for the proper management of C&D materials.

4. PUBLIC FILL MANAGEMENT STRATEGY

The objectives for C&D materials management are to reduce the generation of C&D materials, to maximise reuse and recycling of C&D

materials, and to reduce the disposal of mixed C&D waste in landfills. The HKSAR government's strategy to manage public fill comprises three major tasks: reduce, reuse, recycle. These tasks are implemented by concerted efforts of the construction industry.

(*a*) For public works projects, government departments are required to prepare management plans to critically examine alternatives to reduce the production of public fill during the design stage and to monitor its implementation during the construction stage, so as to reduce the overall quantity of public fill produced at source.
(*b*) Contractors of government works contracts are required to prepare and implement waste management plans to carry out on-site sorting and implement a trip-ticket system to ensure that public fill and C&D waste are delivered to the appropriate reception sites/facilities. Separation of C&D waste (timber, paper, plastic, etc.) from C&D materials aims to prevent reusable public fill being dumped in landfills.
(*c*) A charging scheme for the disposal of C&D materials was introduced to encourage producers to reduce, sort and recycle C&D materials in order that disposal costs are minimised and valuable landfill space preserved. A flytipping spotter scheme has recently been introduced to recruit public support in reporting illegal disposal of C&D materials to prevent any environmental hygiene and nuisance problems associated with illegal flytipping of C&D materials.
(*d*) For private development projects, the HKSAR government is promoting the use of reusable building materials and reduction of C&D materials as part of the award-based comprehensive environmental performance assessment scheme for buildings (CEPAS). The system is formulated to create a positive shift in the current environmental performance of new and existing buildings in HK with the aim of keeping up with global trends in building sustainability through improvements in design, construction/demolition and operation processes with tangible incentives to participating organisations.[18]
(*e*) Public fill is reused in reclamation and site formation works wherever possible. However, this is becoming increasingly difficult because of the drastic reduction of reclamation and site formation works in HK. To tackle this problem, the HKSAR government has commissioned two fill banks to stockpile public fill temporarily until new reclamation projects become available. The HKSAR government is also in discussions with the State Oceanic Administration of China on the feasibility of transporting public fill from HK to some projects in mainland China for reuse in reclamation.
(*f*) Suitable public fill is processed and recycled as aggregates and/or granular materials for use in new construction projects.

In summary, the essence of the approaches to achieve the above objectives is

(*a*) maintenance of a well-managed public filling programme with sufficient public fill reception facilities and barging points at convenient locations
(*b*) encouragement of mixed C&D waste
(*c*) encouragement of reuse and recycling of C&D materials
(*d*) avoidance and minimisation of C&D materials through better design and construction management
(*e*) introduction of a charging scheme for the disposal of C&D materials
(*f*) introduction of the flytipping spotter scheme to recruit public support in reporting and prosecuting illegal disposal of C&D materials
(*g*) introduction of CEPAS for private developments to encourage better management of C&D materials in building design, construction/demolition and operation processes.

5. PUBLIC FILL SERVICES

5.1. Public fill committee

The Public Fill Committee was established by the HKSAR government to implement measures for the promotion of avoidance, minimisation, reuse and recycling of C&D materials. It also oversees the management of the operations and facilities for public filling. In addition, the Public Fill Committee produces and circulates public filling programme information and designates public fill reception facilities for public works projects. The secretariat of the committee is supported by the fill management division of the Civil Engineering and Development Department (CEDD) of the HKSAR government.

5.2. Public fill reception facilities

Public fill reception facilities including public filling areas, public filling barging points, public fill stockpiling areas and fill banks are managed by the CEDD of the HKSAR government to accept public fill.

Currently, facilities accepting public fill materials include Tuen Mun area 38 fill bank (P1), Quarry Bay temporary public filling barging point (P2), Mui Wo temporary public fill reception facility (P3) and Tseung Kwan O area 137 fill bank (P4) (Fig. 4). The fill banks are areas allocated for temporary stockpile of public fill for later use. The public filling barging point is a strategically located facility that utilises barge transportation to transfer public fill from trucks to marine-based public filling areas. Public filling areas are designated parts of development projects that accept public fill for reclamation purpose. Public fill stockpiling areas are sited on newly reclaimed land; public fill is stockpiled as a surcharge to accelerate the consolidation settlement process. After the land has attained the required settlement, the public fill is removed and deposited at another reclamation site. Marine mud, household refuse, plastic, metal, industrial and chemical waste, animal and vegetable matter and other unsuitable materials are not allowed to be disposed of at any public fill reception facility.

Seven outlying islands transfer facilities (located at Mui Wo (T1), Peng Chau (T2), Hei Ling Chau (T3), Cheung Chau (T4), Yung Shue Wan (T5), Sok Kwu Wan (T6) and Ma Wan (T7)) also collect C&D materials on outlying islands in the HKSAR. Locations of these facilities are also shown in Fig. 4.

Waste management facility (Fig. 4)	Type of material accepted	Charge per tonne*: HK$†
Public fill reception facilities (P1–P4)	Consisting entirely of inert C&D materials‡	27
Sorting facilities	Containing more than 50% by weight of inert C&D materials	100
Landfills (L1–L3)‡	Containing not more than 50% by weight of inert C&D materials‡	125
Outlying islands transfer facilities (T1–T7)§	Containing any percentage of inert C&D materials	125

*Except for the outlying islands transfer facilities, the minimum charge load is 1 t. A load of waste in excess of 1 t will be charged at 0·1 t increments. For outlying islands transfer facilities, the charge is HK$12·5 per 0·1 t and the minimum charge load is 0·1 t
†The exchange rate is approximately US$1 = HK$7·8 at the time of writing
‡Rock, rubble, boulder, earth, soil, sand, concrete, asphalt, brick, tile, masonry or used bentonite
§If a load of waste contains C&D materials and other waste, the entire load will be regarded as C&D materials for the purpose of calculating the applicable disposal charge

Table 1. Disposal charges for C&D materials

5.3. Dumping licences

Dumping licences are issued to truck owners free of charge by the fill management division for delivery of public fill to public fill reception facilities. Application forms may be obtained and submitted via the internet. The expiration date of the dumping licence is specified on the licence to indicate when the licensee must apply for a new licence. A dumping label is issued together with the licence for display on the vehicle.

5.4. Trip-ticket system

The HKSAR government has implemented a trip-ticket system in public works contracts for proper disposal of C&D materials at public fill reception facilities or landfills in order to minimise illegal dumping. During the planning stage of a contract, the project officer will seek confirmation from the Public Fill Committee as to whether public fill reception facilities will be available or confirmation from the Director of Environmental Protection as to whether landfill space will be available for the disposal of public fill generated by the specific project.

5.5. Public filling services hotline

A public filling services hotline is provided by the HKSAR government to allow the public to obtain: application forms for dumping licences; information on locations and opening hours of public fill reception facilities; information on procedures for dumping licence applications; and information on appeal procedures in the event of receipt of a warning letter and/or cancellation of dumping licence.

6. REUSE AND RECYCLING

Until 2005, the CEDD operated a pilot C&D material recycling plant within the Tuen Mun fill bank. It processed broken concrete and rock to produce recycled aggregates for use in various public works projects (e.g. concrete production, filter materials, pipe bedding, road sub-base material, paving blocks, granular fill, rock fill and stone columns). In total, the plant produced approximately 540 000 t of recycled aggregates. Upon decommissioning of the plant in June 2005, in the following month the HKSAR government set up a crushing facility in the Tseung Kwan O fill bank to produce Grade 200 recycled rockfill.

Only broken concrete and rock pieces are suitable for recycling into products with market value. Other inert hard C&D materials such as asphalt, tiles, bricks and glass cannot be processed into acceptable and/or marketable products without further research and a change in local market acceptance criteria. Separating concrete and rock pieces from other non-recyclable materials is an onerous and energy-inefficient procedure. It is thus desirable that only concrete and rock, not a mixture with any other non-recyclable materials, are delivered to recycling facilities. Selective demolition and on-site sorting should be adopted for all demolition projects to facilitate recycling as far as possible.

A pilot C&D waste recycling plant was set up at the SENT landfill in 1998 to recover usable materials from mixed C&D waste. Mixed C&D waste with a high proportion of inert content is diverted to the plant and materials recovered returned for beneficial use within the SENT landfill.

7. CONSTRUCTION WASTE DISPOSAL CHARGING SCHEME

A charging scheme for disposal of C&D materials at landfills, sorting facilities and public fill reception facilities was introduced through amendments to the Waste Disposal Ordinance in 2005. The charging scheme came into operation on 1 December 2005 and charging for disposal began on 20 January 2006. The current charge level is summarised in Table 1. Producers of C&D materials (e.g. construction contractors, renovation contractors, premises owners) are required to open a billing account with the EPD and pay disposal charges prior to using any government disposal facilities. Producers are encouraged to reduce, sort and recycle C&D materials so as to minimise their disposal costs and preserve landfill space.

As from 1 December 2005, main contractors undertaking construction work of contract sum HK$1 million or more are required to open a billing account with the EPD solely for the particular contract. Failure to submit an application within 21 days of being awarded the contract is a legal offence. For construction work of contract sum less than HK$1 million, any person such as the owner of the premises where the construction work takes place or his/her contractor can open a billing account with the EPD. The same account can be used for other contracts of value less than HK$1 million each. The premises owner concerned may also engage a contractor with a valid billing account to make the necessary arrangements for C&D materials disposal.

8. FLYTIPPING SPOTTER SCHEME

Implementation of the charging scheme has resulted in an increased level of illegal flytipping of C&D materials, with subsequent environmental hygiene and nuisance problems. Although the EPD takes stringent actions against such illegal disposal, it is extremely difficult to catch and prosecute flytippers with sufficient evidence. The EPD has introduced a flytipping spotter scheme to recruit public support in monitoring and reporting illegal flytipping of C&D materials. Volunteers are invited to participate in the scheme and training programmes provided so that participants have a clear understanding of the legislative provisions and legal procedure relating to their civic duties, evidence to collect, precautions for their personal safety, and so on. The EPD will contact the reporter for more detailed information upon receipt of a flytipping report. If there is sufficient evidence, legal action will be taken against the flytipper and the reporter may be required to testify in court during the prosecution proceedings.

9. COMPREHENSIVE ENVIRONMENTAL PERFORMANCE ASSESSMENT SCHEME FOR BUILDINGS (CEPAS)

The Buildings Department of the HKSAR government devised CEPAS to evaluate the environmental design and performance of buildings in 2006. The scheme is an effort to implement the HKSAR government's initiative to set up a 'green building' label system so as to use market forces to promote environmentally friendly buildings. CEPAS is a holistic assessment tool for various building types with clear demarcation of the entire building life cycle covering the pre-design, design, construction/demolition and operation stages.[18] Specific performance indicators are assigned in the assessment scheme during the construction/demolition stage to encourage contractors to implement effective management to reduce, recycle and reuse C&D materials.[19] A bonus score can be awarded for innovative methods devised by contractors to reduce the generation or display effective management of C&D materials in construction/demolition sites.[19]

10. CONCLUSIONS

Proper, efficient and economical routine management of C&D materials is a challenge facing waste management professionals worldwide. The situation in HK is particularly acute due to its small area, dense population and rapid economic growth and urban renewal over the past few decades.

Various initiatives being implemented by the HKSAR government in both public and private sectors to tackle the problem are presented in this paper. The effectiveness of these initiatives is being closely monitored by the government and adjustments are being made from time to time as required.

ACKNOWLEDGEMENTS

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